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Fiber Quality of Iranian Carpet-Wool Sheep Breeds

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ABSTRACT

This experiment was aimed to identify characteristics and comparative merits of Iranian sheep wool breeds. Fiber characteristics of 75 male and 137 female of 1, 2, 3 and 4 yr of age belonging to Afshari, Zandi, Mehrabani, Lori, and Baluchi sheep breeds were studied. Samples of fiber were taken from the left midside of sheep and analyzed using standard objective measurements for staple length (SL), mean fiber diameter (MFD), coefficient of variation of fiber diameter (FDCV), inner coat fiber ICF, outer coat fiber (OCF), kemp fiber (KF) and yield (Y). A general linear model including sex and age as fixed effects and breed as random effect was used to analyze the data. The mean (and s.e) for SL, MFD, FDCV, ICF, OCF, KF and Y were 110.8±0.1 mm, 36.9±0.5 μm, 50.2%±0.8%, 84.2%±0.6%, 9.8%±0.4%, 5.9%±0.4% and 69.3%±0.7% respectively. MFD of 22% of all wool samples was between 22–30 μm. MFD of a further 36% and 42% of wool samples was between 31–37 μm and coarser than 37 μm. SL of 12% of wool samples was shorter than 100 mm and 38% of samples between 100–120 mm and 50% of samples were longer than 120 mm. There is substantial scope to improve the quality of fiber produced by Iranian sheep breeds through genetic selection.

Key words: sheep, wool, staple length, fiber diameter, fiber types

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi karakteristik dan membandingkan keunggulan domba tipe wool Iran. Karakteristik serat dari 75 ekor jantan dan 137 betina umur 1, 2, 3, dan 4 tahun bangsa domba Afshari, Zandi, Mehrabani, Lori, dan Baluchi diamati pada penelitian ini. Sampel serat diperoleh dari sisi tengah kiri domba dan dianalisa menggunakan pengukuran secara objektif untuk panjang serabut (SL), diameter serat tengah (MFD), koefisien keragaman diameter serat (FDCV), serat lapisan dalam (ICF), serat lapisan luar (OCF), serat kemp (KF), dan perolehan serat (Y). Nilai tengah (dan standar error) untuk SL, MFD, FDCV, ICF, OCF, KF, dan Y secara berurutan adalah 110,8±0,1 mm, 36,9±0,5 μm; 50,2%±0,8%; 84,2%±0,6%; 9,8%±0,4%; 5,9%±0,4%; dan 69,3%±0,7%. MFD 22% dari seluruh sampel wol adalah 22-30 μm. MFD 36% dari sampel wol adalah antara 31–37 μm dan 42% lebih dari 37 μm. SL dari 12% sampel wol lebih pendek dari 100 mm, 38% sampel antara 100-120 mm, dan 50% sampel lebih panjang dari 120 mm. Karakteristik tersebut merupakan lingkup penting untuk meningkatkan kualitas serat yang dihasilkan bangsa-bangsa domba Iran melalui seleksi genetik.

Kata kunci: domba, wol, panjang serabut, diameter serat, tipe serat

INTRODUCTION

Sheep population of Iran was 53.8 million heads in 2008 which ranks 5th rank in the world (FAO, 2010) with 27 well defined breeds. This population of sheep produced annually about 400,000 tones of meat, 820,000 tones of milk, 60,000 tones of wool, 22 million skin pelts and 188,000 tones of guts (Ministry of Agriculture, 2009). More than 1.6 million people are directly involved in sheep breeding with significant role in the economy and livelihood of rural and nomadic societies.

Four major sheep production systems can be distinguished: rural, nomadic, semi-intensive and intensive systems with major concentration on rural and nomadic systems. Semi-intensive system predominantly includes fattening of sheep in large farms, whereas in intensive system, sheep is raised in large agro-industries run by public holdings and cooperatives. On average every rural/nomad household keeps about 95 heads of sheep. More than 96.3% of Iranian sheep population belongs to the fat tailed and the remaining 4% belong to semi-fat

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tailed and tailed breeds. "Zel" is the only tailed breed and the semi-fat tailed breeds are Taleshi and Dalagh (Atabai) which live in northern areas near Caspian Sea.

Sheep are well adapted to local environmental conditions (Yilmaz *et al*., 2003) and Iranian indigenous breeds are dual purpose in which wool comes second after meat production in the farmer's priority and sold in the local market. Wool produced by sheep breeds plays an important role both as an important source of income to farmers and as a supply of raw material for hand-woven carpet. Iran has exported 8 million square meters of hand-woven carpets annually during last two decades.

All Iranian sheep breeds are double-coated and produce carpet wools which contain some proportion of hollow or medullated coarse and resilient hair and kemp fibers and are used in the manufacture of carpets. The fleece of sheep grows from specialized follicles in the skin. While primary follicles bear medullated outer coat coarse fiber (hair) and provide mechanical protection, secondary follicles produce non-medullated inner coat fine fiber or true-wool which provides thermal protection. The fiber diameter and staple length are the most important characteristics. Carpet wool quality and its value are primarily determined by fiber diameter and length which reflect the degree of wool growth and fineness respectively. Presently, little technical data is available on Iranian sheep fiber characteristics. Accordingly this paper studies wool quality and its variation of different sheep breeds in different regions of Iran in order to determine the scope for improvement and future utility.

MATERIALS AND METHODS

Animals and Procedures

A total of 212 sheep (75 males and 137 females) of Afshari, Zandi, Mehrabani, Lori and Baluchi breeds respectively from Zanjan, Qom, Hamedan, Lorestan, and South Khorasan provinces were used in this study. The sheep grazed all year but their diets were supplemented during winter with limited amount of forage and grain (containing 15 g N kg^{-1} dry matter and 9.1 MJ) and were housed at night during severe weather conditions. Sheep were grouped into 4 age groups: 1, 2, 3, and 4 yr old.

Wool sampling coincided with the maximum wool growth prior to the shearing of wool. In order to facilitate sampling, sheep were restrained in a lateral position and about 10 grams of fiber containing hair, kemp (medullated) and true wool (non-medullated) from the left mid-side site was cut from a 5 × 5 cm^2 close to the skin using regular scissors. Mid-side samples are common when fleece traits are considered (Ahtash, 2005; Cimen, 2006). Each sample was separately packaged and labeled with ear tag number, age, gender and the breed of the sheep.

Fiber characteristics of raw wool samples were measured in the Animal Science Research Institute Fiber Laboratory in Karaj, Iran. A quarter of each sample was weighed with a digital scale. Contaminants such as dandruff, vegetable matter, scurf and soil were separated. To determine the percentage of clean wool weight, net bags containing samples without contaminants were weighed immediately, immersed in three scouring bowls solution containing 0.3% of Na_2CO_3 and 0.1% of soap and water and stirred for 15 minutes at a temperature of 52±3 °C. This procedure was repeated once more but only with warm water. Washed samples were oven-dried and weighed and the percentage of clean wool weight was estimated. The mean fiber diameter of the washed wool sample was measured using a projection microscope. The average staple length for each wool sample (in triplicates) was measured to the nearest 0.1 cm. The number of non-medullated inner coat fiber, medullated outer coat hair fiber and medullated kemp fiber were measured (IWTO, 1952).

Statistical Analysis

Analysis of variance was performed using a general linear model. Differences between means were tested using Duncan's new multiple range test. The statistical model used for cashmere goats of different age, sex and breed was:

$$Y_{ijk} = \mu + \alpha_i + S_j + B_k + (\alpha S)_{ij} + (\alpha B)_{ik} + (SB)_{jk} + (\alpha SB)_{ijk} + \varepsilon_{ijk}$$

where: Y_{ijk}: dependent variables; μ: the overall mean; α_i: the effect of age (i=1, 2, 3, 4); S_j: the effect of sex (j=1, 2); B_k: the effect of breed (k=1, 2, 3, 4, 5), ε_{ijk}: residual error; $(\alpha S)_{ij}$: interaction between age and sex groups; $(\alpha B)_{ik}$: interaction between age and breed groups; $(SB)_{jk}$: interaction between sex and breed groups; $(\alpha SB)_{ijk}$: interaction between age, sex and breed groups.

All values were expressed as least square means ± SEM with $P<0.05$ was considered to be statistically significant.

RESULTS AND DISCUSSION

For the measured wool characteristics total mean and standard errors are provided for different breeds, sexes and ages (Table 1), minimum and maximum values are given (Table 2) and different ranges of fiber are shown (Table 3). Twenty two and 36% of all wool samples had a fiber diameter between 22-30 and 31-37 μm respectively. A further 42% of the wool samples were coarser than 37 μm. All samples were longer than 80 mm but shorter than 147 mm with 12% less than 100 mm, 38% between 100 and 120 mm and 50% longer than 120 mm. 67% of all samples had a percentage of inner coat fiber greater than 80 while 28 and 5% of wool samples had a non-medullated inner coat fiber percentage of 65-80 and less than 65 respectively.

Yield and Percentage of Wool Types

Average yield was 69.3%±0.7% (Table 1) with an individual sheep range of 30.9% to 87.4% (Table 2). Males and one year old sheep had significantly higher percent-

age of yield than females and older sheep. Zandi breed had 63.2%±1.6% of yield which was the highest among the breeds.

The average percentages of inner coat, outer coat and kemp fibers were 84.2%±0.6%, 9.8%±0.4%, and 5.9%±0.4% respectively (Table 1). There was no significant difference in the percentage of inner coat fiber between male and female sheep. However one year old sheep with 87.3% had highest inner coat fiber than older sheep. Zandi breed with 93.7%±1.9% had significantly highest inner coat fiber than other sheep breeds.

The 9.8% medullated OCF in the present study is similar to that reported for Arabi (10.9%) (Ashmawi & El-Azzawy, 1980), lower than those in the Awassi sheep in Jordan and Iraq (12%) (Tabbaa *et al*., 2001), Moghani sheep in Iran (18.36%) (Farahvash *et al*., 2010) and higher than those in the Ossimi (5.3%) and Rahmani (2.3%) sheep (Maria *et al*., 1992), Arkhamerino × Ghezel and Arkhamerino × Moghani crossbred sheep (7.1% and 8.1% respectively) (Esfandyari *et al*., 2011), Ghezel sheep (9.42%) (Farahvash *et al*., 2010). Proportion of medullated fiber in fine wool breeds is about 0.1%-0.5% (Lupton *et al*., 2004). The amount of medullated fibers in current study falls within the range of 5%-25% reported for carpet-wool breeds in Asia (Mehta *et al*., 2004). No significant difference in inner coat fiber percentage between males and females of Iranian breeds of the present study was in agreement with the findings of Jordanian Awassi sheep breed. Tabbaa *et al*. (2001) reported 11% and 10% medullated inner coat fiber for male and female Awassi lambs respectively. One year old sheep had highest percentage of inner ICF percentage and decreased with age. Tabbaa *et al*. (2001) also reported that the percentage of inner coat decreased with advancing age in Awassi and Barki sheep breeds. One year old sheep had the lower percentage of kemp fiber than older sheep, a finding in agreement with Awassi sheep (Tabbaa *et al*., 2001).

Large variation in the percentage of KF was found between breeds of sheep which is in agreement with the findings of Wurzinger *et al*. (2005), Mokhber (2005) and Safari *et al*. (2005). Large variation in the percentage of ICF (58.9%-98.6%) and undesirable KF (0%-33.6%) demonstrate the possibility for improving Iranian sheep fleece quality by selection. Farmers need to be trained on selection criteria for breeding rams based on subjective wool assessment to avoid keeping breeding males with high kemp percentage.

Mean Fiber Diameter and Staple Length

Wool MFD was 36.9±0.5 μm (Table 1) with an individual sheep range of 22.7–60.0 μm (Table 2). Zandi and Balouchi breed had the finest and longest wool while Mehrabani sheep had the coarsest and shortest with 73% of wool samples coarser than 37 μm. While Baluchi and Zandi wool is used in making fine carpets, Mehrabani wool is used in very rough and bulky appearance carpets indicating the need for breeding programs to decrease the fiber diameter and increase the staple length.

Overall fiber diameter of wool in this study is comparable to Middle Eastern carpet wool sheep breeds, 36.0 μm for Awassi (Tabbaa *et al*., 2001), 35.4 μm for Ossimi and 31.5 μm for Rahmani (Maria *et al*., 1992), 38.4 μm for Barbary (Akraim *et al*., 2008) and 39.1-40.2 μm for Karakaya (Cimen, 2006). Even though not significant, males had slightly lower fiber diameter than females. One year old sheep had significantly lower fiber diameter than older sheep. Zandi, Baluchi and Lori sheep with respective MFD of 30.6±0.7, 31.0±0.4 and 32.8±0.8 μm had the lowest fiber diameter. 22%, 36%, and 42% of

Table 1. Mean (±s.e.) of wool characteristics for different breeds, sexes, and ages

		No	SL (mm)	MFD (μm)	FDCV (%)	ICF (%)	OCF (%)	KF (%)	Y (%)
Mean			110.8±0.1	36.9±0.5	50.2±0.8	84.2±0.6	9.8±0.4	5.9±0.4	69.3±0.7
			**	NS	**	NS	NS	NS	**
Sex	Male	75	113.7±0.1^{a}	36.2±0.7	47.4±1.3^{a}	86.0±1.0	9.4±0.8	4.8±0.6	72.0±1.0^{a}
	Female	137	116.9±0.2^{b}	37.1±0.6	51.3±0.9^{b}	83.5±0.8	10.0±0.5	6.4±0.5	68.3±0.9^{b}
			*	*	**	**	NS	**	*
Age	1	53	104.7±0.2^{a}	34.2±0.6^{b}	47.2±1.5^{b}	87.3±1.2^{a}	8.9±0.9	3.8±0.6^{b}	73.4±1.1^{a}
	2	59	112.6±0.2^{b}	38.1±0.8^{a}	53.3±1.1^{a}	82.0±1.0^{b}	10.5±0.6	7.1±0.6^{a}	67.0±1.2^{b}
	3	44	113.3±0.2^{b}	36.2±1.0^{ab}	49.2±2.3^{ab}	85.4±1.7^{ab}	8.8±1.0	6.1±1.0^{a}	68.7±1.8^{b}
	4	56	122.1±0.3^{c}	37.9±1.0^{a}	49.3±1.6^{ab}	83.5±1.4^{ab}	10.4±0.9	6.2±0.9^{a}	69.3±1.4^{b}
			*	*	*	*	*	*	*
Breed	Afshari	68	110.7±0.1^{b}	39.5±0.6^{a}	53.6±1.0^{b}	77.1±0.8^{c}	14.0±0.5^{a}	8.7±0.5^{a}	64.4±1.0^{a}
	Zandi	21	120.0±0.2^{c}	30.6±0.7^{b}	43.4±1.3^{c}	93.7±1.9^{a}	6.1±1.9^{b}	0.8±0.3^{b}	63.2±1.6^{b}
	Mehrabani	41	90.1±0.1^{a}	42.1±1.2^{a}	60.7±2.2^{a}	84.8±1.4^{b}	5.5±0.7^{b}	9.5±0.9^{a}	76.5±1.3^{a}
	Lori	31	120.9±0.2^{c}	32.8±0.8^{b}	39.7±1.7^{c}	91.6±1.5^{a}	7.4±1.1^{b}	1.0±0.5^{b}	74.0±1.8^{a}
	Balouchi	51	130.3±0.1^{d}	31.0±0.4^{b}	42.8±1.2^{c}	92.7±0.6^{a}	6.1±0.5^{b}	1.2±0.2^{b}	75.6±1.3^{a}

Note: * and ** significantly different at P<0.05 and P<0.01 respectively. Y= yield, MFD= mean fiber diameter, FDCV= coefficient of variation of fiber diameter, SL= staple length, ICF= non-medullated inner coat fiber, OCF= medullated outer coat fiber, KF= medullated kemp fiber.

Table 2. Minimum and maximum values of wool characteristics

			SL (mm)	MFD (μm)	FDCV (%)	ICF (%)	OCF (%)	KF (%)	Y (%)
Sex	Male	Min	80.0	26.7	27.7	60.0	0.5	0.0	30.9
		Max	133.5	56.9	87.7	98.6	35.1	19.2	89.6
	Female	Min	100.9	22.7	26.7	58.9	0.4	0.0	39.3
		Max	147.0	60.0	88.6	99.6	31.8	33.6	88.3
Age	1	Min	80.0	22.7	27.7	60.0	0.4	0.0	50.2
		Max	110.2	45.9	81.5	98.9	35.1	18.4	87.1
	2	Min	100.0	25.2	30.6	58.9	0.9	0.0	39.3
		Max	120.5	60.0	76.2	99.1	31.8	22.9	89.6
	3	Min	100.2	24.2	28.8	59.4	0.5	0.0	30.9
		Max	127.3	56.9	87.7	99.1	24.9	21.9	86.7
	4	Min	109.6	26.7	26.7	58.9	0.4	0.0	39.4
		Max	147.0	60.0	88.6	99.6	27.9	33.6	87.4
Breed	Afshari	Min	100.0	26.7	28.2	58.9	3.2	0.5	39.3
		Max	130.8	60.0	82.5	95.2	31.8	28.4	86.7
	Zandi	Min	110.0	25.2	32.7	60.0	1.2	0.0	47.2
		Max	140.0	38.9	54.1	99.0	35.1	4.9	74.3
	Mehrabani	Min	80.0	30.7	27.7	58.9	0.4	2.3	55.7
		Max	110.4	60.0	88.6	96.7	17.5	33.6	89.6
	Lori	Min	110.2	25.9	26.7	67.4	0.4	0.0	52.4
		Max	140.4	45.7	75.9	99.6	23.1	16.3	88.3
	Balouchi	Min	120.0	22.7	28.9	77.9	0.5	0.0	30.9
		Max	147.0	42.2	70.4	98.9	16.2	7.8	87.4

Note: * and ** significantly different at P<0.05 and P<0.01 respectively. Y= yield, MFD= mean fiber diameter, FDCV= coefficient of variation of fiber diameter, SL= staple length, ICF= non-medullated inner coat fiber, OCF= medullated outer coat fiber, KF= medullated kemp fiber.

Table 3. Classification of the incidence (%) of sampled wool based on mean fiber diameter (MFD), staple length (SL) and non-medullated inner coat fiber (ICF)

	MFD	%	SL	%	ICF	%
All Breeds	22-30	22	<100	12	<65	5
	31-37	36	100-120	38	65-80	28
	>37	42	>120	50	>80	67
Afshari	22-30	5	<100	0	<65	9
	31-37	36	100-120	60	65-80	48
	>37	59	>120	40	>80	43
Zandi	22-30	60	<100	0	<65	5
	31-37	35	100-120	62	65-80	5
	>37	5	>120	38	>80	90
Mehrabani	22-30	3	<100	85	<65	5
	31-37	24	100-120	15	65-80	15
	>37	73	>120	0	>80	80
Lori	22-30	35	<100	0	<65	0
	31-37	52	100-120	10	65-80	13
	>37	13	>120	90	>80	87
Baluchi	22-30	43	<100	0	<65	0
	31-37	55	100-120	4	65-80	4
	>37	2	>120	96	>80	96

wool samples had a fiber diameter of 22-30, 31-37, and grater than 37 μm respectively (Table 3). The impact of age could be associated with larger body size and reduced skin follicle density and competition for nutrients and therefore fiber diameter of older sheep increases. In contrast with the present study, increasing age had no significant effect on fiber diameter in Awassi and Arabi sheep (Tabbaa *et al*., 2001, Ashmawi & El-Azzawy, 1980) possibly because the animals were younger.

The overall coefficient of variation of fiber diameter was 50.2%±0.8% (Table 1) with an individual sheep range of 26.7%–88.6% (Table 2). There was significant difference in the percentage of coefficient of variation of fiber diameter between different sexes, ages and breeds of sheep. A significant effect of sex on coefficient of variation of fiber diameter in sheep of current study is in agreement with the results found in Naeini sheep (Dashab *et al*., 2006) and Arkhamerino × Ghezel and Arkhamerino × Moghani crossbred sheep (Esfandyari *et al*., 2011). The impact of sex on coefficient of variation of fiber diameter could be associated with hormonal differences between both sexes.

Average wool staple length was 110.8±0.1 mm (Table 1) with an individual sheep range of 80-147 mm (Table 2). Males had significantly shorter staple length than females and one year old sheep had significantly shorter staple length than older sheep. Twelve percent of wool samples had a staple length lower than 100 mm, 38% in the range of 100-120 mm and 50% longer than 120 mm (Table 3). There was significant difference in the staple length of different breeds. Mehrabani and Balouchi breeds had the shortest and longest staple length respectively. The staple length of Iranian sheep breeds of the present study is lower than that of Awassi sheep in Jordan 140.0 mm (Tabbaa *et al*., 2001) and Barbary sheep in Libya 120.2 mm (Akraim *et al*., 2008) but higher than Arabi (Ashmawi & El-Azzawy, 1980), Ossimi and Rahmani sheep (Maria *et al*., 1992). A significant effect of age and sex on staple length is in agreement with Tabbaa *et al*. (2001).

Fiber Shedding Observation

Fiber shedding in Afshari breed was noticeable and started from neck extending to belly and rump areas as a result of follicle shutdown. Structure of fiber, inner root sheath and outer root sheath cells in inactive follicles were either absent or disrupted. In such follicles the outer root sheath cells were often columnar and radially or spirally arranged in contrast to the randomly arranged cells in normal follicles.

It was observed that Afshari sheep was the only breed that had fiber shedding. Shedding is also common in double-coated feral sheep such as Merino breed in Arapawa Island (Orwin & Whitaker, 1984); however the level of shedding which causes complete wool casting in latter breeds is much higher. Smaller secondary follicles which produce finner fibers shutdown prior to larger secondary follicles (Ansari-Renani *et al*., 2007) which could have a negative impact on fiber diameter.

Shedding in Afshari sheep commenced on the neck, chest and shoulders and spread to the back and rump. This sequential, bilaterally-symmetric pattern has been also reported in cashmere goats (Ansari-Renani *et al*., 2011) and camels (Ansari-Renani, 2008, Ansari-Renani *et al*., 2010). Unlike natural shedding, cortisol injected Merino sheep, shedding of fiber starts from rump and belly areas extending to shoulders (Ansari-Renani *et al*., 2007).

CONCLUSION

There are differences between Iranian sheep breeds in the way the fibers they produce which contributes to different fleece characteristics such as fiber diameter, staple length and the level of medullation. Sheep in wool characteristics indicating the potential to improve wool quality and the need for adopting proper management and selection methods.

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